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ADDITIONAL DATA CONCERNING THE PRESERVATION OF MINERALS*

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Some years ago the writer prepared a paper on "The Preservation of Mineral Specimens,"¹ in which he indicated several ways by which minerals are susceptible to change when exhibited or stored in museums and gave a list of minerals that are peculiarly liable to damage.

In the interval, since the publication of the original article, several other interesting cases of change in minerals have been brought to the attention of the writer by discussion in *THE AMERICAN MINERALOGIST*, by personal communications and by observation and experiment. In certain instances an explanation of the extreme scarcity of rare minerals is presented. A few cases of preservation by association and possibly destruction because of associated minerals have also come to light.

The problems that present themselves most forcefully in the case of minerals are light effects, temperature effects, and chemical effects. Needless to say there is no museum that is equipped so as to display all its material without damage.

Two cases of oxidation of native metals have come to light. The late E. O. Hovey called to the writer's attention the fact that certain specimens of the native iron from Greenland oxidized to a crumbly mass when stored indoors, while a specimen which was kept outside his window on the window sill showed no signs of crumbling. In a similar manner it has been found at the Royal Ontario Museum of Mineralogy that the native lead from Sweden becomes covered with a gray pulverulent coating, evidently resulting from the oxidation of the lead or of some associated mineral. In neither case is there a satisfactory explanation of the peculiar behavior of these substances but it is evident that definite precautions must be taken. Possibly a lowering of the temperature would prove sufficient in both cases.

* Presented at the sixth annual meeting of The Mineralogical Society of America, New Haven, Conn., Dec. 28, 1925.

¹ *Am. Mineral.* 7, 59-63, (1922).

The conditions for the oxidation of sulphides and arsenides are difficult to determine but peculiar differences with the same mineral are frequently noticed. Gersdorffite crystals embedded in calcite from the Crean Hill mine near Sudbury have remained brilliant and untarnished for years. The same mineral, however, from the Silver Bar mine in Cobalt in association with smaltite, niccolite, cobaltite and rammelsbergite tarnishes in a few weeks on the polished specimens to a brown, and no means is known for preventing this change. Both types have been analyzed and the only factor that can be inferred to account for the rapid change in the material from Cobalt is that the particular association of minerals hastens the change. Conversely, specimens of pure polydymite from the Vermilion mine near Sudbury oxidize rapidly and disintegrate under ordinary museum conditions while the same mineral when associated with chalcopyrite remains bright for years. The pure material disintegrates much more slowly when kept absolutely dry and warm. In this case the chalcopyrite appears to exert a protective influence.

Brilliant marcasite crystals have frequently been found by the writer on old mine dumps in association with calcite, barite and fluorite while specimens from certain lead and zinc mines gradually disintegrate in the mineral cases. The extremely rapid oxidation of marcasite in coal is difficult to explain but is a well known fact.

Recently the writer, in collaboration with his colleague Professor T. L. Walker, has made some experiments with the oxidation of certain arsenides and sulphides in an atmosphere saturated with moisture as well as in pure oxygen and other gases with water.² Bright rammelsbergite became covered with green nickel bloom in less than a week at room temperatures. Niccolite that was associated with the rammelsbergite became coated more slowly but an intimate mixture of niccolite and breithauptite remained perfectly brilliant. In its relation to the preservation of these materials it emphasizes the necessity of storing them in a dry place. Apparently breithauptite is not only extremely resistant to weathering but protects niccolite from oxidation.

The lighting problem in most cases does not present serious difficulties though in addition to the minerals mentioned in the previous article Walther³ has called attention to the alteration

² *Univ. of Toronto Studies, Geol. Ser.*, 20, 41-48.

³ *Am. Mineral.*, 7, 145, (1922).

of cinnabar, chrysoprase, and green fluorite from exposure to light. A remarkable instance of change of color by exposure to light is furnished by the hackmanite from Dungannon township, Ontario⁴ and other places, which becomes white in from ten to twenty seconds when exposed to direct sunlight.

Another example of complete bleaching is afforded by the topaz from Thomas Mountain, Utah, which is usually observed as colorless transparent crystals. Crystals which have been protected from light are various shades of claret.

A mineral that is said to become much darker on exposure to light is azurite. Tyuyamunite changes from lemon yellow to dirty greenish yellow in a few minutes in direct sunlight. Hisingerite from the Minnie Moore mine, Blaine county, Idaho, is claret red when fresh but rapidly turns black and then slowly to dark brown.⁵

Dr. L. J. Spencer has called the attention of the writer to the fact that colorless vivianite when broken open turns blue in a short time. In this case it would appear that the conditions of equilibrium are destroyed by the rupture of the crystal surface.

Rapid temperature changes seldom manifest their effects under museum conditions so as to be visible. The only case that the writer has observed that is probably to be referred to this cause is the development of two well defined cleavage cracks in a water clear crystal of fluorite in one of the exhibition cases of the Royal Ontario Museum of Mineralogy.

A feature that must be taken into consideration immediately after collecting certain minerals is the possibility of intermolecular liquid which on evaporation leaves crystals of a material that had been dissolved with a consequent shattering of the crystals of the host mineral. This was called to the attention of the writer by F. N. Ashcroft, Esq., who observed that certain analcite crystals from below high tide level, which had not been soaked in fresh water to remove brine, became shattered while those that had been immersed for some time in fresh water remained clear and free from shattering.

To the minerals that melt at low temperatures we must add asphaltum and ozocerite.

Loss of water at ordinary temperatures was discussed at length in the preceding article. A striking case of this sort has developed

⁴ *Univ. of Toronto Studies, Geol. Ser.*, 20, 5.

⁵ Hewett and Schaller: *Am. J. Sci.*, Ser. V, 10, 33.

in the meantime with epsomite. Some large lumps of this mineral from Basque Siding, Ashcroft, B. C., have been on exhibition for several years in a large glass container. The material is as bright as when first collected. A large reserve specimen wrapped in paper has become chalky and friable.

In discussion, Dr. A. C. Lane called attention to the fact that minasragite which had been stored in a possibly damp basement during the summer was represented by a green spot in the tray.

Dr. G. F. Kunz pointed out that silver and lead, as well as almost any mineral, would be better preserved by dipping them in a solution of alcohol (95%) and collodion (5%). The collodion can be removed again by alcohol if it is desirable to use the material for investigation.

Mr. G. L. English stated that specimens of native lead from Sweden at Ward's Natural Science Establishment had remained bright and unaltered.

DOUBTFUL MINERAL SPECIES AS ILLUSTRATED BY "FAROELITE"*

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"Faroelite" is a mineral name of so little importance that any printed discussion of it may seem unwarranted, but it is believed that some parts of such a discussion may be made of so general a character as to warrant its presentation.

That the great majority of common silicate minerals vary considerably in composition is now so well established and generally recognized that the obvious application of this fact to concrete cases may fairly be expected; yet articles still appear which seem to ignore it completely. Before the development of our knowledge of isomorphous variations in mineral systems this was more or less excusable; but at the present day it is surely not going too far to hold that *two samples of silicate minerals, which are closely similar (but not identical) chemically and also crystallographically, probably belong to an isomorphous series or system, and names implying the existence of two different independent species should not be used for such cases unless accompanied by unquestionable evidence that the substances are not isomorphous.*

* Presented at the sixth annual meeting of The Mineralogical Society of America, New Haven, Conn., Dec. 28, 1925.

As a corollary it may be mentioned that, unless the laws of isomorphous replacement are correctly understood and applied, it is obvious that no simple formula should be expected to result from recalculations of analyses of examples of such isomorphous systems. For example, it is not possible, and should not be possible, to derive simple ratios between any two oxides composing plagioclase of composition $\text{Ab}_{47}\text{An}_{53}$, nor of any other composition, unless the ratio between Ab and An *happens* to be simple. In spite of this fact many writers on mineralogy are so accustomed to the idea that every analysis, if made accurately on pure material, must correspond to some simple formula that they use all sorts of devices to derive such a formula. Thus, in a recent excellent discussion of a silicate the authors state that five analyses are "decidedly similar" and "consistent" although they show the following variations:¹

OMITTED		RANGE		RANGE	
21.14	SiO_2	35.43 to 42.05	{	$\text{SiO}_2 + \text{TiO}_2$	35.43 to 42.05
0.03	TiO_2	0.00 to 0.27			
2.28	Al_2O_3	0.00 to 4.53	{	$\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$	32.81 to 34.71
57.43	Fe_2O_3	29.70 to 34.09			
0.62	FeO	0.00 to trace			
1.51	CaO	1.76 to 3.06	{	$\text{CaO} + \text{MgO}$	7.24 to 13.63
2.47	MgO	4.91 to 10.42			
9.91	$\text{H}_2\text{O} +$	5.19 to 9.73	{	Total H_2O	13.29 to 17.51
4.59	$\text{H}_2\text{O} -$	6.81 to 8.51			

Even this degree of "similarity" is only obtained by arbitrarily omitting from consideration one analysis which the authors describe as representing the "most homogeneous" material at their disposal, which they use to establish the chief physical characters of the mineral.

This silicate always occurs in a finely granular state in complex rocks so that it is exceedingly difficult to obtain pure material for analyses; and the authors deserve high praise for the successful performance of such a difficult task. They report that they obtained "clean crystalline" material from six different localities, and used this for their analyses.

This tendency to write a formula for nearly every mineral analysis disregards the fact that nearly all minerals are isomor-

¹ The figures are purposely quoted incorrectly, but they are in all cases of the right order of magnitude.

phous systems and, unless the isomorphism happens to be confined to elements of the same valence, the usual methods of deriving formulas are incorrect and misleading. It is now well established that isomorphism involving elements of unlike valence is the usual condition, especially in aluminum silicates, as illustrated in the plagioclase series, the orthoclase-celsian series, the scapolite series, the pyroxene system, the amphibole system, the mica system, the chlorite system, and probably in the zeolites.

Many other illustrations of this tendency to write unwarranted formulas could be cited, including some from excellent articles in the latest numbers of *THE AMERICAN MINERALOGIST*; it is because the tendency is so wide spread and well nigh universal that the error involved in it is important. This should make it clear that this criticism is directed against the present practice of many mineralogists and not especially against the authors of the particular study quoted.

The writer does not pretend to be able to give the correct interpretation of the analyses cited, but he can see no justification for averaging them together and claiming that the simplest numbers thus obtained represent the composition of the mineral. One might just as well expect to obtain the correct chemical formula for plagioclase by averaging all analyses of that mineral. Even if the analyses happened to be distributed uniformly through the plagioclase series the result obtained would not give a correct idea of the composition of the mineral; on the contrary, the formula deduced would be $\text{NaCaAl}_3\text{Si}_5\text{O}_{16}$. Any simple ratios obtained by such a process must be regarded as purely accidental. Any formula derived in such a way would hide entirely the presence of an isomorphous series, and would require fixed physical properties. The authors of the new study state that the formula they have obtained for it "may be confidently quoted as that of the normal" mineral. And yet their own account of the physical properties of the mineral plainly requires wide variations in its composition,² since the optic angle measured about X varies from 25° to 120° , the birefringence varies from 0.035 to 0.047, and the index of refraction (N_m) varies from 1.65 to 1.75, even if one disregards

² The authors recognize variations in composition in that MgO is supposed to be "replaced" by CaO, and Fe_2O_3 by Al_2O_3 , to some extent, but these variations are distinctly less than the variations disregarded by the formula and are clearly inadequate to explain the variations in optic properties, especially since increase of iron corresponds with decrease of mean refractive index, a condition contrary to that in other isomorphous systems.

the sample which the authors state "shows the physical properties in greatest perfection." If this sample be included, the variations in index and birefringence are nearly doubled, and the variations in composition are much increased.

In the writer's opinion the same condition, though in less degree, exists in regard to the mineral known as thomsonite. It has long been regarded as having the formula $(\text{Ca}, \text{Na}_2) \text{Al}_2\text{Si}_2\text{O}_8 \cdot 2\frac{1}{2} \text{H}_2\text{O}$. Wherry³ has recently argued that so-called thomsonite really includes two distinct minerals, each of fixed composition, one being the true thomsonite, assumed to have the fixed formula $\text{NaCa}_2\text{Al}_5\text{Si}_5\text{O}_{20} \cdot 6\text{H}_2\text{O}$, and the other being "faroelite," supposed to be also of fixed formula. However, it is so difficult to determine from the analyses the precise character of this fixed formula of "faroelite" that Wherry himself in two discussions⁴ of the matter gives it in two ways which differ from each other by an amount more than one third as great as the difference between one of them and Wherry's fixed formula for true thomsonite.

A mere inspection of the diagram prepared by Wherry shows that there is no break or discontinuity in chemical variability of minerals known as thomsonite, provided the analyses can be trusted. Wherry would explain this condition by assuming that nearly all of the samples analyzed consisted of mixtures of two or more zeolites; and in support of this assumption he cites the fact that Bøggild has observed intergrowths of thomsonite with mesolite, natrolite, etc., and the further fact that he finds optical evidence (consisting of differences in birefringence and refringence) of the presence of two (or more) zeolites in more than four out of five of some 25 samples examined.

Under these circumstances it seems necessary to call attention to the fact that the presence of two substances optically (and chemically) somewhat unlike in a given mass is not proof that the substances are not isomorphous; if it were, it would be easy to prove from many examples in igneous rocks that various members of the plagioclase series⁵ are not isomorphous since one type is commonly formed as phenocrysts with another type in the ground-

³ *Am. Mineral.*, 8, 121, (1923).

⁴ *Am. Mineral.*, 8, 121, (1923); and 10, 342, (1925).

⁵ Wherry considers the previous reference to the plagioclase series unjustified because in it there is optical evidence of isomorphism; however, at the time Fouqué wrote (1894) there was a considerably greater gap in measured refractive indices between anorthite and labradorite in that series than now exists between admitted thomsonite and "faroelite."

mass of the same rock. Proof that two types occurring together are not isomorphous would be supplied if it could be shown that they were formed simultaneously from the same solution.

It may be worth while to compare the physical properties of Wherry's special type of thomsonite and his "faroelite." They are both orthorhombic, of long fibrous habit, with one perfect and one distinct longitudinal cleavage, the distinct cleavage (which may be taken as 100) being normal to the perfect cleavage (which may be taken as 010); both are commonly colorless and transparent or translucent, with vitreous to pearly luster; both fuse very easily to a transparent globule; both gelatinize with hydrochloric acid. According to Des Cloizeaux,⁶ "faroelite" is a (siliceous) variety of thomsonite, and, like it, has parallel extinction with the optic plane normal to the elongation and an optic angle (2E) of about 90° about the positive acute bisectrix, which is normal to the best cleavage.

The following measurements of optical properties of thomsonite and "faroelite" have been made by Wherry, or accepted as satisfactory by him:

LOCALITY	N _g	N _m	N _p	OBSERVER	REFERENCE
Peekskill, N. Y.	1.543	1.531	1.527	Phillips	<i>Am. Mineral.</i> , 9, 240.
Franklin, N. J.	1.542	1.532	1.530	Gordon	<i>Am. Mineral.</i> , 8, 125.
Kilpatrick,	1.540	1.525	1.520	Wherry	<i>Am. Mineral.</i> , 8, 124.
WHERRY'S "faroelite"					
Table Mt., Colo.	1.518	1.513	1.512	Wherry	<i>Am. Mineral.</i> , 8, 124.

According to this table the gap in observed indices of refraction is considerable, and Wherry emphasizes this point and makes use of it to distinguish between thomsonite and "faroelite" by using a liquid with $N = 1.518$, in which all the indices of thomsonite are said to be higher, while all those of "faroelite" are said to be lower. Wherry⁷ states definitely that all three indices of "faroelite" are "lower than the lowest of thomsonite." However, in another place⁸ he gives the indices of "faroelite" as: $N_g = 1.518$, $N_m = 1.513$, $N_p = 1.512$, all ± 0.005 ; therefore the upper limits of the indices attributed to "faroelite" are: $N_g = 1.523$, $N_m = 1.518$, $N_p = 1.517$. Moreover, the indices of refraction of thomsonite have been measured by other observers with results as follows:

⁶ MANUEL DE MINÉRALOGIE, 1, 374-378, (1862).

⁷ *Am. Mineral.*, 10, 345.

⁸ *Am. Mineral.*, 10, 346.

LOCALITY	N _g	N _m	N _p	OBSERVER	REFERENCE
Jakuben, Bohemia	1.534	1.523	1.521	Scheit	<i>T. Min. Pet. Mit.</i> 31, 495.
Faroe Islands	1.530	1.520	1.517	Gordon	<i>Am. Mineral.</i> , 8, 125.
Fritz Isl., Pa.	1.527	1.516	Gordon	<i>Am. Mineral.</i> , 8, 125.

Therefore, on the basis of published data there is little, if any, gap in the series of values of indices of refraction in the thomsonite—"faroeelite" series.

In view of all the facts, the writer believes that it is much more reasonable to consider that these mineral samples belong to a single isomorphous series rather than to assert that one of them represents a new and independent species.

However, the question can be tested in various ways. The writer had at his disposal only a few samples of thomsonite so that search for material which would come in the supposed gap seemed futile at first. Nevertheless, measurements were made by two methods, with interesting results.

Dr. T. B. Williams used the ordinary method with immersion liquids and daylight and obtained the following data:

LOCALITY	N _g	N _m	N _p	SOURCE OF MATERIAL
Kilpatrick	1.540+	1.528±	1.526+	<i>Phila. Acad. Sci.</i> , No. 18724
Table Mt., Colo.	1.528±	1.520+	$\left\{ \begin{array}{l} < 1.515 \\ > 1.510 \end{array} \right.$	<i>Univ. Wis.</i> , No. 1640
Table Mt., Colo.	1.526+	1.520—	$\left\{ \begin{array}{l} < 1.515 \\ > 1.511 \end{array} \right.$	<i>U. S. Nat. Mus.</i> , No. 83262
Faroe Isl.	$\left\{ \begin{array}{l} < 1.530 \\ > 1.526 \end{array} \right.$	1.520±	$\left\{ \begin{array}{l} < 1.515 \\ > 1.511 \end{array} \right.$	<i>Phila. Acad. Sci.</i> , No. 13903
Table Mt., Colo.	1.526—	$\left\{ \begin{array}{l} < 1.520 \\ > 1.517 \end{array} \right.$	$\left\{ \begin{array}{l} < 1.515 \\ > 1.511 \end{array} \right.$	<i>U. S. Nat. Mus.</i> , No. 83260

Dr. R. C. Emmons used the much more accurate dispersion method with a monochromator, a refractometer, and careful temperature control. In order to obtain results rapidly he measured only the intermediate index of refraction because that is easily found on any prismatic crystal or elongated cleavage fragment. He obtained the following values for sodium light:

LOCALITY	N _m	TEMPERATURES	SOURCE OF MATERIAL
Table Mt., Colo.	1.513	35°C	<i>U. S. Nat. Mus.</i> , No. 83260
Table Mt., Colo.	1.516–1.520	34°C	<i>U. S. Nat. Mus.</i> , No. 83260
Faroe Islands	1.512, 1.517, 1.520	32°C	<i>Phila. Acad. Sci.</i> , No. 13903
Faroe Islands	1.521	26°C	<i>Phila. Acad. Sci.</i> , No. 13903

In summary the measured values of N_m in thomsonite show the following series: 1.513, 1.516, 1.520, 1.523, 1.525, 1.530, 1.532. Therefore the supposed gap in the optic properties does not exist, if the evidence furnished by the measurements of Scheit, Gordon, Williams, and Emmons can be trusted.

At the suggestion of Mr. S. G. Gordon the matter was next tested by X-ray methods. The X-ray pattern of a sample of natrolite from Bergen Hill, N. J., is compared with the pattern given by thomsonite from the Harz Mts. in the upper half of Fig. 1. It is evident that the two space-lattices are much alike, but, nevertheless, show sharply defined differences such as could

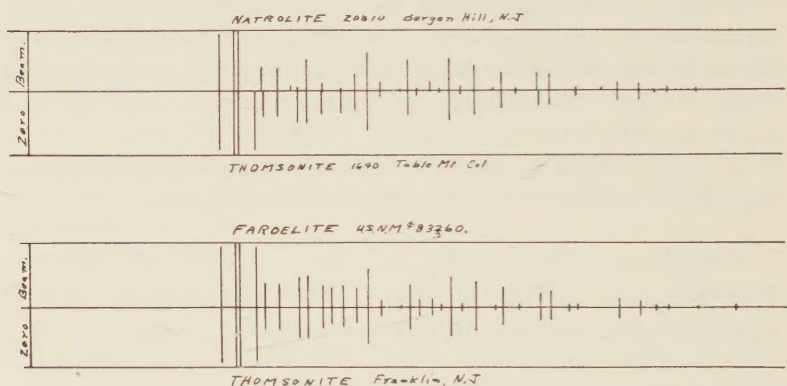


Fig. 1. X-ray patterns from natrolite, thomsonite and "faroesite." Lengths of lines are proportional to their intensity. X-ray tests and drawing thereof made by C. H. Stockwell.

not exist in two substances belonging to an isomorphous series. This is quite in harmony with the fact that both are orthorhombic with axial ratios not extremely different, and that Scheit⁹ found thomsonite growing on natrolite so as to completely surround it, the vertical axes being parallel and the vertical pinacoids of thomsonite being as nearly as possible parallel with the prism faces of natrolite. That is, the space-lattices are so similar that one kind controls the orientation of the other kind (when growing upon it), but does not cause completely parallel orientation nor gradation from one to the other. Therefore there can be no doubt that thomsonite and natrolite are not strictly isomorphous.

⁹ *Tsch. Min. Pet. Mtl.*, 31, 495, (1912)..

In order to test the matter further a sample of thomsonite from Franklin Furnace, N. J. (type material of Wherry's thomsonite) was obtained through the kindness of Mr. S. G. Gordon and Mr. George Vaux, Jr., and a sample of the type material of Wherry's "faroelite" from Table Mountain, Colorado, was obtained from the U. S. National Museum through the courtesy of Dr. W. F. Foshag. The X-ray patterns from these two samples are shown side by side in the lower half of Fig. 1. It is clear that they are substantially identical.

This is not of itself conclusive proof that the two belong to a single isomorphous series since rare cases seem to exist in which non-isomorphous substances give substantially identical patterns. It does show that thomsonite and "faroelite" are more closely alike than thomsonite and natrolite, and, indeed, have substantially identical space lattices.

In summary, it has been shown that: (1) An isomorphous series should be expected in a silicate mineral showing variations in composition. (2) According to the chemical analyses such a series seems to exist in thomsonite (including "faroelite"). (3) The X-ray patterns support the view that an isomorphous series exists in thomsonite which includes the so-called "faroelite." (4) There is no gap in the variations in optic properties in thomsonite. (5) The variations in optic properties therefore prove the existence of an isomorphous series.¹⁰

¹⁰ As Dr. Wherry's work on thomsonite-faroelite is brought into question by the above article he has stated (private communication) that while he does not agree with several conclusions therein reached, he does not propose to discuss the matter further without additional evidence. It is hoped to have new analyses made on optically controlled "high silica thomsonite", but he has been unable to locate any such material which proves optically homogenous. If any reader of this journal has a specimen which he believes will answer this description, Dr. Wherry would appreciate it greatly if he would furnish him with a gram or two for such study. The silica should exceed 38% and any one refractive index should be constant throughout the specimen to ± 0.003 . Localities where high silica material has been reported may be found in Dana or Doelter. Editor.

NICKELIFEROUS VERMICULITE AND SERPENTINE
FROM WEBSTER, NORTH CAROLINA¹CLARENCE S. ROSS, *United States Geological Survey*

AND

EARL V. SHANNON, *United States National Museum*

INTRODUCTION

The present paper comprises the results of a continuation of the mineralogic investigation of a series of specimens collected by the senior author, during the past summer, in the Webster, North Carolina, dunite area which has been described by Pratt and Lewis.² An account of the nickeliferous deweylite from this locality has previously been presented,³ and the green micaceous mineral here described was mentioned.

NICKELIFEROUS VERMICULITE

The mineral first to be described is a peculiar micaceous material that becomes plastic when wet, which occurs with the deweylite about one-half mile south of the Tuckasegee River and about 1 mile east of Webster where the presence of these minerals has led to some desultory prospecting.

The nickeliferous vermiculite forms lens-shaped veins, which reached a maximum length of nearly a meter and a width of 2 to 8 centimeters. They often contain or are bordered by films of porous, white sinter-like chalcedony, and are imbedded in the siltlike soil that has resulted from the decomposition of the dunite. Light green actinolite, pale lavender kämmererite, a colorless chlorite, and the cream-colored serpentine described below are associated with the nickeliferous vermiculite. The latter mineral has clearly formed, in part at least, by the replacement of actinolite, and it has probably also replaced kämmererite. The actinolite now forms isolated island-like areas that are the residual remains of a single crystal. The development of the platy micaceous mineral at the expense of acicular actinolite proves that the structure of the former is not inherited, but is a property of the mineral itself.

¹ Published by permission of the Director of the United States Geological Survey and the Secretary of the Smithsonian Institution.

² Pratt, Joseph Hyde, and Lewis, J. Volney: *N. C. Geol. Survey*, 1, 92-95, (1905).

³ Ross, Clarence S., and Shannon, Earl V.: The so-called genthite from Webster N. C., *Am. Mineral*, 10, 444-445, (1925).

The nickeliferous vermiculite is not euhedral, but some plates suggest an hexagonal outline. It commonly occurs in distorted or helminth-like piles of crystal plates, but some of it forms felted masses of platy crystals. The piles of crystal plates are 5 to 30 mm. long and 1 to 10 mm. in diameter. The felted material is fine-grained and some of the plates are not over 0.01 mm. in diameter. The distorted form of the crystals and the accompanying warping of the plates may be due, in part, to the plasticity of the mineral, but the curved or radial shape seems to be a normal structure that is characteristic of the substance. The wet mineral is very plastic, notwithstanding the comparatively large size of the crystal plates. On heating the mineral exfoliates and expands into accordion-like masses in the manner characteristic of vermiculites. It greatly resembles talc but does not have a talcose feel, and is more sectile than talc.

The cleavage is very perfect parallel to the base and the laminae are flexible but are inelastic and fragile. The luster is silky on the base and dull in other crystallographic directions. The hardness is approximately 1. Optically the mineral is uniaxial to biaxial with $2V=0^{\circ}-8^{\circ}$. It is negative in character with the acute bisectrix, X, normal to the base. The apparent biaxial character of most of the crystals plates may be due to a slight strain but it seems more probable that the mineral is truly biaxial. The refractive indices are $\alpha=1.542$, $\beta=\gamma=1.573$. The double refraction is thus moderately high, $\gamma-\alpha=0.031$. The dispersion, $\rho>\nu$, is weak. In thin section the mineral is perceptibly pleochroic with X pale green, Y and Z pale yellowish to brownish-green. Absorption $Z=Y>X$.

The color in the hand specimen is bright green when wet, bright apple to light green when dry. The occurrence of the larger plates in a finer groundmass, coupled with the visible remnants of other minerals and some limonite stain gives hand specimens of the mineral a very heterogeneous and unpromising appearance, but selected crystal plates are very pretty and indicate a clear-cut mineral.

Two lots of nickeliferous vermiculite were prepared for analysis and the results are given below. The analysis given under column 1 was made upon hand picked, pearly, brilliant pale yellow-green, talc-like scales that averaged about 4 mm. in diameter. That given under column 2 was made upon material composed of evenly-

sized, bright apple green scales that had been freed from a small proportion of earthy impurities by washing. Microscopic examination showed that both samples were free from all the associated minerals, but No. 1 contained a small number of scales that were slightly stained with iron oxide.

The analysis in column 1 was made upon 0.1000 gram of material. The accurate analysis in 2 was made upon ample material while the ratios derived from this analysis are given in column 3. These indicate that the formula representing the analysis is: $3\text{MgO} \cdot \text{NiO} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 6\frac{1}{2}\text{H}_2\text{O}$

The theoretical composition calculated from this formula is given in column 4. Analysis No. 2 shows, however, that the nickel-magnesia ratio is accidental, and that these bases are isomorphous, so that the formula is best written: $4(\text{Mg}, \text{Ni})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 6\frac{1}{2}\text{H}_2\text{O}$.

The mineral is apparently common at the locality and after it had been studied a large number of specimens were found in both the mineral and ore collections of the National Museum. These were all labeled "garnierite," when received, while all the nickeliferous deweylite in the group of specimens was labeled "genthite."

CHEMICAL COMPOSITION AND RATIOS OF NICKELIFEROUS VERMICULITE

	1	2	3		4
SiO_2	35.70	34.76	.580	.580	.96×4 36.8
Al_2O_3	12.00	14.86	.146	.163	1.08×1 15.6
Fe_2O_3	3.40	2.74	.017		
FeO	0.41	.006	.467	1.03×3
CaO	0.32	0.40	.007		
MgO	25.90	18.18	.454		
NiO	5.34	11.25	.151	.151	1.00×1 11.4
$\text{H}_2\text{O}+120^\circ$	12.00	12.60	.700	.988	1.00×6½ 17.8
$\text{H}_2\text{O}-120^\circ$	7.00	5.20	.288		
Total	101.66	100.45			100.00

NICKELIFEROUS SERPENTINE

A mineral occurring in small amounts with the micaceous material described above has been analyzed and found to be serpentine. This occurs as small cream-colored to greenish-white rounded pellets. It has a mean refractive index of 1.558. The analysis, made upon a little less than a quarter of a gram of selected pure material, gave the following results:

NICKELIFEROUS SERPENTINE	
SiO ₂	39.36
Al ₂ O ₃	2.76
Fe ₂ O ₃	2.77
CaO	1.32
MgO	36.71
NiO	2.57
H ₂ O+120°C	13.85
H ₂ O-120°C	1.54
Total	100.88

This chemical composition is typical of serpentine, except for the small proportion of nickel, and the optical and other physical properties are those of serpentine.

DUMORTIERITE FROM NEVADA

ERNEST E. FAIRBANKS, *Reno, Nevada*

INTRODUCTION

Dumortierite-sericite schist is being utilized in the production of refractories. In view of this application, the identification of dumortierite assumes added importance. A dumortierite of a Nevada schist gave such strong dispersive effects that ordinary light could not be employed in the determination of refractive index data. Since mineralogists have come to place considerable importance on refractive index determination, the difficulty encountered in the case of this mineral is worth recording. The probable source of the various colors of dumortierite is also mentioned.

OCCURRENCE

A schist occurring on the west slope of Lincoln Hill in the Rochester mining district, Nevada, appears to have been first described by Jones¹ as a result of a reconnaissance through the district in 1913. The schist is better referred to as a dumortierite-sericite schist than as a mica-tourmaline schist as first suggested by Dr. Jones on the basis of a rather hasty reconnaissance. While tourmaline was common in the veins of Lincoln Hill it was rarely found in the schist.

¹ Geology of Rochester, Nevada: *Min. & Sci. Press*, **106**, No. 20, May 17, 1913, p. 738.

ORIGIN

This schist is referred to as a dumortieritized trachyte by Knopf² who presents the following statements regarding its origin: "The extensive development of dumortierite and associated minerals is clearly due to the action of boron-bearing gases, which have undoubtedly escaped from an underlying granite magma and permeated the trachytes as they traveled upward through a closely spaced network of fractures. These emanations were evidently rich in silicon, aluminum, and boron and deficient in alkalis and sulphides."

Jones states that "it is not improbable that the granodiorite that appears near . . . to the north, underlies the area and the more intense metamorphism of the rocks and the mica-tourmaline veins of Lincoln Hill is due to its influence."

Since the material from Lincoln Hill possesses a marked schistose structure it will be referred to in this paper as a schist. The schist has since been found at several other localities near the huge mass mapped by Knopf.

A brief note recently appeared³ reporting the purchase of an occurrence of the schist located in Limerick Canyon, not far from Lincoln Hill, by the Champion Spark Plug Company.

A news item has also recently appeared in the *Reno Evening Gazette* stating that a deposit of "dumortierite, a mineral highly useful in the manufacture of spark plugs" occurring in Gypsy Queen Canyon, 6 miles northeast of Oreana, Nevada, has been purchased by interests representing the Champion Company." This occurrence is located near the Limerick Canyon schist.

The new use for andalusite in the manufacture of spark plugs is now well-known. The use of dumortierite is a more recent development. Vernadsky^{3a} found dumortierite to be converted into sillimanite at white heat. We now know that this "sillimanite" is in reality mullite. Cristobalite and perhaps an aluminum borate would be expected to accompany the mullite. It is evident from Vernadsky's work why dumortierite should have been considered of possible value in the manufacture of super-refractories.

² Geology and ore deposits of the Rochester district, Nevada: *U.S.G.S. Bull.* 762, 1924, pp. 19-20.

³ *Eng. & Min. Jour.-Press*, 120, No. 17, Oct. 24, 1925, p. 666.

^{3a} *Bull. Soc. franc. mineral.*, 13, 256 (1890).

DETERMINATION OF DUMORTIERITE

The following optical data were determined for dumortierite free from alteration found in the powdered samples of the lilac colored schist from Limerick Canyon. The mineral is biaxial (—) with alpha parallel to the elongation. Birefringence amounts to $.011 \pm$. An elongated cleavage fragment slightly less than .04 mm. in thickness and oriented normal to the obtuse bisectrix, exhibited the pleochroism, alpha distinct light blue and beta colorless. The dispersion of the optic axes with $\rho < \nu$ was sufficiently strong to make the accurate determination of the refractive indices impossible in white light. Dispersive effects were found over a long range of refractive index liquids using white light. With light practically equivalent to Li-light (wave length $665\mu\mu$), alpha was determined as being closer to 1.677 than to 1.678. The variation of these two liquids was probably not greater than ± 0.001 . The liquids were prepared especially for this determination with the aid of the Zeiss form of the Abbé refractometer.

A search through Larsen's tables⁴ supplemented by a table of new minerals described since the appearance of Larsen's tables, fails to indicate any mineral other than dumortierite with properties similar to those determined for the Nevada mineral.

A very decided test for titanium was obtained by means of the carbonate fusion method, indicating the existence of an appreciable quantity of titanium in a specimen of schist which microscopic examination showed to be dumortierite with but a trace of andalusite present. Schaller has also obtained a decided test for titanium in a dumortierite from the mass described by Knopf.⁵

The refractive indices for dumortierite found in the literature indicate that alpha is commonly as high as that determined for the Limerick Canyon mineral which contains an appreciable amount of titanium. The presence of an appreciable quantity of either TiO_2 or Ti_2O_3 in minerals is usually accompanied by an increase in the refractive indices since the specific refractive energies are high for these constituents. Thus 2% Fe_2O_3 and

⁴ The microscopic determination of the nonopaque minerals: *U.S.G.S. Bull.* 679, 1921.

⁵ *Op. cit.*, p. 19.

⁶ The system $\text{Al}_2\text{O}_3\text{--SiO}_2$, N. L. Bowen and J. W. Greig: *Jour. Am. Ceramic Soc.*, 7, No. 4, April 1924, p. 252.

⁷ A titaniferous augite from Ice River, British Columbia: C. H. Warren and J. A. Allan: *Am. Jour. Sci.*, 43, Jan. 1917, p. 77.

TiO_2 ⁶ present in mullite increases the refractive index of alpha 0.6%. In the case of augite approximately 5% TiO_2 ⁷ has been found to increase the refractive index of alpha about 1%. The above considerations appear to indicate that titanium is generally present and if this is true the various colors of dumortierite can be explained by the presence of this element.

The specimens of schist studied consist chiefly of altered, fibrous material giving aggregate polarization effects and varies from nearly opaque to nearly transparent.

The dielectric constants were determined for the Nevada dumortierite and also for typical andalusite, and cyanite.

Dumortierite	(violet)	Nevada	17
Dumortierite	(red)	Nevada	17
Andalusite	(bluish)	California	8
Andalusite	(bluish)	Tyrol	12
Cyanite	(blue)	Nevada	7-9

$\lambda = \text{infinite}$ Error ± 1

It would be interesting to obtain data from other specimens since the determined values are not far apart. Dielectric constants obtained from some minerals which resemble each other very closely have been found to differ widely.

DUMORTIERITE AS A COMMERCIAL MINERAL

ALBERT B. PECK, *University of Michigan*

INTRODUCTION

About two years ago attention was called to the rapid rise in commercial importance of andalusite, as a result of the discovery of a large deposit of it in California.¹ One might assume that the development of a mineral of such great value from the ceramic standpoint, accompanied as it was by an almost revolutionary change in the composition of certain types of porcelains, would justify a pause in the search for better material. However, as a result of the fact that modern research is continually striving for the better, we are able at this time to add another hitherto rare and practically useless mineral to the list of those of real value. The mineral referred to is dumortierite. As in the case of the California andalusite, the present deposit of dumortierite is owned and has been developed by the Champion Porcelain Company of

¹ *Am. Mineral.*, 9, 123-9 (1924).

Detroit, Michigan. A few notes dealing with the occurrence of this mineral and its use may therefore be of general interest to mineralogists.

LOCATION AND OCCURRENCE

This deposit of dumortierite is located near what is known as Limerick Canyon, slightly west of the northwestern corner of what is ordinarily considered to comprise the Rochester Mining District of Nevada. A precise location can not be given, owing to the confusion of names existing to describe the various canyons of the region. Knopf² mentions the occurrence of dumortierite in an altered trachyte at Lincoln Hill, which is considerably to the southeast of the dumortierite of Limerick Canyon. The trachyte contains irregular areas of dumortierite and is profusely cut by veinlets up to six inches in width.

The dumortierite, which led to the discovery of the Champion mine, was first noted as veinlets cutting a large dike-like mass of andalusite and quartz, but in a canyon bottom to the west of this, some large boulders of dumortierite were found, one weighing probably 30 tons. Inasmuch as no masses that would weigh more than a ton could be observed in the andalusite-quartz mass, a prospect tunnel was started in the canyon to the west of the andalusite-quartz "dike" in an effort to locate the source of the large boulders. While this work was in progress, the main body of dumortierite was cut. For a considerable distance the width is fully 14 feet and the present development indicates a "vein" fully 250 feet long. This dumortierite is distinctly massive in character with a decided schistose structure and is rather vein-like in form.

MINERALOGY

PHYSICAL PROPERTIES. Thus far no perfect crystals are available. In one or two specimens, small crystals surrounded by quartz and andalusite have been observed, but they are not more than one quarter inch in length or over one thirty-second inch in width. The typical mode of occurrence resembles a schist. The masses exhibit a distinct cleavage and split rather easily into slabs, but these are exceedingly tough and resistant to transverse stresses. This accounts for the difficulty found in crushing it in practice, although it grinds with fair ease. In a few places veinlets composed of fibers perpendicular to the walls have been noted.

² *U.S. Geol. Sur. Bull.* 762.

The color of the schist varies from light to dark pink through lilac and lavender to medium blue. Some shade of pink is the most common color, a very unusual color for dumortierite. Some specimens show both pink and blue colors. The masses are hard as well as tough and will scratch glass. The specific gravity, although varying slightly, is generally near 3.30. All the crystals are microscopic in size and hence the other physical properties are relatively unimportant.

MICROSCOPIC PROPERTIES. It is only when subjected to microscopic examination that the true nature of the rock is revealed. It is composed of very minute prismatic needles of dumortierite very intimately intergrown with muscovite. The intergrowth is so close that it is impossible to free one from the other. Frequently, numerous needles of dumortierite can be seen penetrating completely through some of the larger plates of muscovite. Muscovite usually comprises from 12 to 18 percent of the rock. Andalusite and quartz are also present in small and very constant amounts of less than 5 percent each. The only other constant associate is rutile. This is present as very minute grains evenly scattered through the rock. In this way it resembles the occurrence of rutile with the California andalusite.

OPTICAL PROPERTIES. The optical constants for Nevada dumortierite do not appear to vary greatly for differently colored material, as is shown by the following indices of refraction:

	α_{Na}	β_{Na}	γ_{Na}	
pink massive	1.677	1.685	1.690	all ± 0.003
lavender massive	1.675	1.685	1.690	
light blue crystals	1.675	1.685	1.692	

In elongation $c = \gamma$; the optic angle in all cases is moderate, about $30-40^\circ$; the dispersion of the optic axes is $\rho > \nu$, but it does not appear to be unusually strong. Only alpha shows pleochroic colors and that varies from red violet to lavender blue, according to the color of the mineral.

CHEMICAL COMPOSITION. The chemical composition of this massive material on a loss-free basis is as follows:

SiO ₂	37.05 Per cent	Equivalent to	
Al ₂ O ₃	55.01	dumortierite	75.33 Per cent
TiO ₂	0.63	muscovite	14.16
B ₂ O ₃	4.65	excess SiO ₂ (partly quartz)	8.53
Others	2.66	others	1.98

It is quite apparent from this that the massive rock is very high in dumortierite. Undoubtedly, part of the titanium is combined in the dumortierite, replacing Al_2O_3 or SiO_2 . As is evident from the presence of microscopic rutile grains mixed with the dumortierite, one can not ascribe all of the TiO_2 present as the coloring agent of the dumortierite itself. For this reason the ordinary qualitative carbonate fusion test upon this material does not necessarily prove that the pleochroism of this dumortierite is due to TiO_2 . Before an accurate quantitative investigation could be undertaken, some method would have to be devised to eliminate the rutile.

The relation of titanium to the color of the mineral is a matter easier to speculate upon than to prove. One wonders if the state of oxidation of titanium may not influence the color of the resulting mineral. Whether, for example, if present as Ti_2O_3 , a blue color may not result, and when replacing SiO_2 in the form of TiO_2 , the red colors may not be formed. In this connection there is an interesting association to be observed in some of the veinlets which run through some parts of the andalusite "dike." These veinlets often show blue dumortierite next to the walls and grade into pink dumortierite at the center. It does not seem impossible to assume that under changing conditions as the veinlets were formed, the titanium first may have been in the form of Ti_2O_3 , replacing the Al_2O_3 with the resulting blue color, and that under later conditions it was oxidized to the TiO_2 form and replaced the SiO_2 , in which condition it imparted a pink color. On the other hand the possibility of the presence of manganese or other elements should not be entirely excluded. The presence of free rutile, however, also seems to indicate that the dumortierite has absorbed as much titanium as could be expected of it.

BEHAVIOR UPON FIRING

To the ceramist the most important property of a mineral is its behavior upon firing. An indication of the importance of this was briefly outlined in the earlier paper on andalusite.³ Suffice it to say in the case of dumortierite that it breaks down gradually at a comparatively low temperature, beginning at cone 10 (approximately 1250°C) or a little lower. The result of this dissociation is similar to that of andalusite; namely, the formation of a very

³ *Am. Mineral.*, 9, 123-9 (1924).

intimate mixture of mullite crystals ($3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$) in glass. When the breakdown first occurs there is no definite orientation of the mullite crystals with reference to the original dumortierite grain. The mullite crystals are exceedingly small and also lack definite form. Furthermore, they grow at a very slow rate as the firing temperature is increased.

When the dumortierite rock is fired it expands somewhat as it dissociates and decreases in specific gravity. At the same time it changes in color to a pure white and takes on a dull porcelain-like luster, the former being a highly desirable property from the ceramic standpoint.

USE

Although dumortierite dissociates into a mixture of mullite and glass at a rather low temperature, the resulting product is very refractory. This is due to the fact that its composition lies near that of mullite, according to the alumina-silica diagram of Bowen and Greig.⁴ According to Dr. Fairchild⁵ test cones formed from the powdered rock fuse sharply at 1810°C . At cone 36 half over (approximately 1800°C) the same material sintered somewhat but showed no signs of deformation and maintained even the sharpest edges without rounding due to fusion. It is apparent, therefore, that it has great possibilities from the standpoint of refractoriness.

The remarkably pure white color produced in this material when fired, is direct proof of the nearly complete absence of accessory metallic oxides, only two, Fe_2O_3 and TiO_2 , being present. This is very important from the practical standpoint because comparatively small quantities of such compounds may impart a shade of color to the resulting ware; or still less desirable, they may produce small dark colored spots upon a white background. Thus, because of its white-firing property, this dumortierite could be used in even the very highest grade of porcelain, if it were desired to do so.

Although the use of dumortierite is still in the experimental stage, enough has been learned to show that it has other properties of great value for its use as a refractory and also as a constituent of porcelains. It is now being used experimentally, replacing a part of the andalusite used in special porcelains.

⁴ *J. Am. Cer. Soc.*, **7**, 238-54 (1924).

⁵ Unpublished data from U. S. Bureau of Standards.

As was the case for andalusite, this dumortierite rock is used in its original state without concentration; in fact, owing to its fine grain and intimate relation to the muscovite, concentration would probably be impossible.

ACKNOWLEDGMENT

Like andalusite, the discovery and development of this dumortierite deposit and its rise to the rank of a mineral of commercial importance, are both largely the direct result of patient and persistent search for the seemingly impossible thing, and too much credit in this connection can not be given Dr. J. A. Jeffery, President of the Champion Porcelain Company.

LITHIOPHILITE AND OTHER RARE PHOSPHATES FROM PORTLAND, CONNECTICUT*

J. F. SCHAIRER, *Yale University*

In studying the mineralogy and paragenesis of the pegmatite at the Strickland Quarry, Collins Hill, Portland, Connecticut, several lithium minerals associated with the manganese phosphates were found. The minerals occurring together are spodumene, lepidolite, manganapatite, lithiophilite, dickinsonite and hureaulite in albite and quartz. Only very small amounts of dickinsonite and hureaulite are found with the lithiophilite which is itself not abundant. W. G. Foye¹ has reported the occurrence of lithiophilite from this locality but gives no data.

Through the generosity of Professor Foye of Wesleyan University, the large specimen of lithiophilite (Wesleyan Museum No. 10615) was placed at the writer's disposal for chemical study. The specimen consists of a large mass of light orange colored lithiophilite without crystal form, in platy albite with muscovite, quartz and a very little dickinsonite as accessory minerals.

Pure material for analysis was separated very easily by hand picking and examining the fragments under the microscope to insure a homogeneous sample. Examination showed the indices of refraction to be between 1.66-1.67. The analysis follows:

* Presented at the sixth annual meeting of The Mineralogical Society of America, New Haven, Conn., Dec. 28, 1925.

¹ W. G. Foye, *Am. Mineral.*, 5, 120 (1920).

	I	II	Mean	Ratios	
MnO	40.20	40.05	40.13	0.566	} .639 = 2.02
FeO	5.05	5.27	5.16	0.072	
CaO	0.07	0.09	0.08	0.001	
Li ₂ O	8.63	8.59	8.61	0.288	} .319 = 1.01
Na ₂ O	0.53	0.45	0.49	0.008	
H ₂ O	0.41	0.41	0.41	0.023	
P ₂ O ₅	44.91	44.90	44.90	0.316	} = 1
Insoluble	0.16	0.15	0.16		
	99.96	99.91	99.94		

Formula: $\text{Li}_2\text{O} \cdot 2(\text{Mn,Fe})\text{O} \cdot \text{P}_2\text{O}_5$ or $\text{Li}(\text{Mn,Fe})\text{PO}_4$.

In order to record the complete method for the analysis of phosphates containing FeO, MnO, CaO, MgO the details for their separation are also given.

To determine the constituents, other than the alkalis and water, dissolve about 1 gm. in HCl, filter off the insoluble residue, wash and weigh it; add some HNO₃ to the filtrate and remove the acids by evaporation. Take up in water with addition of a little HNO₃, if necessary; precipitate while hot with Na₂CO₃, filter and wash moderately. The filtrate, which is called A, may be slightly turbid without objection. Dry the precipitate, ignite in platinum, burning the filter paper separately and fuse with 4-5 parts of Na₂CO₃ or K₂CO₃. (In case the substance has no insoluble residue it is fused directly with Na₂CO₃.) Treat the mass with hot water, adding a few drops of alcohol in order to reduce man-ganic acid. Filter and wash with hot water. The filtrate is added to A, the combined solution is acidified with HCl, heated to boiling until CO₂ is removed, then a slight excess of NH₄OH is added and the small precipitate of phosphate is collected and washed. The filtrate is called B. The small precipitate is dissolved in HCl, as is also the main residue of oxides obtained by fusion and the solutions are united. Nearly all the acid is removed by evaporation and a precipitation of basic ferric acetate is made in the usual manner. This precipitate contains a little phosphate. Dry it, ignite it separately from the paper and fuse it with alkaline carbonate to which a very little KNO₃ is added. Treat the mass with hot water, filter and wash. This filtrate is called C. Dissolve the residue of Fe₂O₃ in HCl, precipitate with NH₄OH, wash free from chlorides, weigh Fe₂O₃ and calculate FeO. The filtrate from the Fe(OH)₃ should be treated with (NH₄)₂S, and if traces of MnS separate after standing they should be collected, dissolved in

HCl and added to the main manganese solution mentioned beyond, just before precipitating with HNa_2PO_4 .

Acidify the solution C, boil off CO_2 and add it to B. Determine P_2O_5 in the united solution with magnesium mixture as usual, or better determine P_2O_5 in a separate sample with molybdic acid mixture.

Heat the filtrate and washings from the basic ferric acetate precipitate, after all the iron has been removed, without diminishing the original volume by concentration, and add a rather large volume of bromine water. Heat upon the steam bath until the precipitate becomes flocculent, filter and wash with hot water. Test the filtrate by adding more bromine water and some sodium acetate, and then determine any CaO and MgO that it may contain by the usual methods.

Dissolve the MnO_2 precipitate in SO_2 and warm water upon the filter, then determine MnO in the usual way as $\text{Mn}_2\text{P}_2\text{O}_7$. Alkalies are determined in the usual manner. H_2O is determined by the method of Penfield or by heating in a combustion tube and collecting the water in weighed CaCl_2 and P_2O_5 tubes.

S. L. Penfield² pointed out the isomorphism between triphylite and lithiophilite. Recently K. K. Landes³ has found the lithiophilite from Buckfield, Maine, to be very near the pure lithiophilite end member with only 2.94% FeO. The material from Portland, Connecticut is another link in the isomorphous series.

On one specimen of spodumene there were small masses of lithiophilite containing small, micaceous flakes of green dickinsonite. The indices of refraction of the dickinsonite were slightly above and below 1.66. The mineral showed the perfect basal cleavage. Not enough material was available for a chemical study.

The rare mineral hureaulite was identified on one specimen in very small quantities with lithiophilite. The hureaulite is deep orange-red in color and its indices of refraction are between 1.65 and 1.66. The mineral easily fuses to an orange non-magnetic globule. A partial quantitative analysis was made on a very small sample (0.03 gm.) and the hureaulite from Portland, Connecticut, proved to be almost identical chemically with the Branchville material described by Brush and Dana.⁴

² S. L. Penfield, *Am. Jour. Sci.*, **17**, 226-9 (1879).

³ K. K. Landes, *Am. Mineral.*, **10**, 382-3 (1925).

⁴ Brush and Dana, *Am. Jour. Sci.*, **39**, 207-11 (1890).

Occurring near the lithiophilite is dark bluish-green apatite. A sample was selected by careful hand picking and the manganese determined. There was 8.52% MnO present. Associated with the apatite were albite, quartz, columbite and muscovite.

When more of these phosphates are found it is hoped that a complete chemical investigation may be undertaken. In conclusion I wish to express my thanks to Professor W. G. Foye for the lithiophilite for analysis and to Professor H. W. Foote for his advice and encouragement during this investigation.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, February 11, 1926

A stated meeting of the Philadelphia Mineralogical Society, attended by twenty-one members and six visitors, was held on the above date. Vice-president H. W. Arndt presided.

An amendment to the By-Laws, providing that hereafter stated meetings shall be held on the first Thursday instead of the second Thursday of each month, was unanimously adopted. It will go into effect with the April meeting.

The society was then addressed on the subject of *Mining Districts in Michigan and Ontario* by the secretary, who described his experiences in collecting minerals while attending the summer session of the University of Michigan at Ann Arbor in 1925, and a subsequent three weeks trip through the iron and copper districts of northern Michigan and the nickel and silver regions of Ontario, returning to Philadelphia by way of Toronto and Niagara Falls.

Among the localities visited from Ann Arbor were Maybee, Monroe, and Oakwood, Michigan, and the crystal cave on the island of Put-in-Bay, in Lake Erie.

The speaker then travelled northward to Ishpeming, Michigan, and visited the Holmes Mine of the Cleveland Cliffs Iron Company. In the Keweenaw Peninsula copper district, centered about Houghton, Michigan, many mines were found to be closed down, but a few specimens were collected.

In the Sudbury nickel district of Ontario the Creighton and Worthington Mines were visited, as were also the smelters of the International and the Mond Nickel Companies. At Cobalt, Ontario, many specimens were collected from the dumps and stamp mill of the Nipissing Mine.

An enjoyable sojourn at the Frontier Mine, Silver Centre, Ontario, as the guest of the Mining Corporation of Canada, Ltd., was followed by an interesting three-day hike through the woods in the vicinity, after which the journey southward to Toronto was made by rail. After a visit to the Royal Ontario Museum of Mineralogy at Toronto, and a sojourn of a few days at Niagara Falls, the speaker returned to Philadelphia.

The talk was illustrated by numerous lantern slides and by a large number of specimens, including samples of celestite, halite, iron ores, native copper, copper arsenides, pentlandite, gersdorffite, niccolite, smaltite, wire silver, and argentite.

HORACE R. BLANK, *Secretary*

BOOK REVIEW

A COMPREHENSIVE TREATISE ON INORGANIC AND THEORETICAL CHEMISTRY. J. W. MELLOR. Six volumes published, royal 8vo, total 5988 pages and 1261 diagrams. Longmans, Green and Co., London, 1922-1925.

This exhaustive compilation of the facts and theories of inorganic chemistry, contains a vast amount of information of direct interest and value to the mineralogist, particularly under the headings of history and occurrence devoted to each element, and the minerals thereof, of which it is an essential constituent. In addition, a very complete bibliography of references is given at the close of each main division.

As an example, 42 pages are given concerning the occurrences of the rare earths and the formulas and properties of their minerals, as well as some sixty-two complete analyses and upwards of a thousand original references. The discussion of the nature of these rare and complex species and the relations between certain groups is frequently suggestive.

Many pages are devoted to admirable articles on such subjects as crystals, their internal structure and seven styles of architecture, growth and x-ray analysis; composition of the Stassfurt salt beds and the synthesis and genesis of diamonds.

Volume six is almost exclusively devoted to silica and the silicates. Hitherto, the best reference books covering the field of inorganic chemistry have been available only to those familiar with German, more specifically, the famous "Handbuch(s) der anorganischen Chemie" by Abegg and by Gmelin-Kraut. Since a comparable treatise in English may now be had, it is urged that all interested in mineralogy as a science, should familiarize themselves with these encyclopedic storehouses of the data of the inorganic world.

O. IVAN LEE

ABSTRACTS

FOUR RECENT PAPERS ON THE FELDSPARS. HAROLD L. ALLING, Rochester, N. Y.

During my studies of the feldspars, I have received four papers some of which may not be readily available to mineralogists in this country. Abstracts of these papers are offered below:

Johansson, Dr. H. E., of the Geol. Survey of Sweden. "ON THE COMPOSITION AND FORMATIONAL CHANGES IN THE FELDSPARS." "Om. Faltspaternas Sammansättning och Bildningsbetingelser." *Geol. Fören Förhandl.*, No. 237, Bd. 27, Häft 6, pp. 338-346, 1905.

Johansson collected about 1000 analyses of feldspars and found that 470 of them were sufficiently accurate for interpretation. He divided the feldspars into two groups; first, those which occur in igneous rocks which contain no quartz such as syenites, nepheline-syenites, diorites and gabbros, together with metamorphic equivalents. Second, feldspars that occur in igneous rocks containing quartz such as the granites. These two groups of feldspars he has plotted on triangular diagrams. The three components are orthoclase, albite and anorthite which can be abbreviated to Or-Ab-An. Johansson draws the probable solubility lines on these triangles. The areas occupied by the above mentioned feldspars show where homogeneous single-phase feldspars occur. He evidently includes in this group, however, many perthitic feldspars. The plotting of the analyses of potassium feldspars from

pegmatite granites and quartz-bearing gneisses show that there is a concentration of feldspars from 20 to 30 mol. % Ab, 2 to 4 mol. % An. and the almost complete absence of feldspars in the interval 30 to 50 mol. % Ab. Johansson concludes, therefore, that there is not a continuous series between Or and Ab, which is in perfect accord with the conclusions of other investigators. The diagram showing the feldspars from quartz-free rocks indicates that the break between Or and Ab is not as pronounced as in the former case.

He comments on the significance in the difference in the structure and composition of the feldspars derived from volcanic rocks which have cooled rapidly from those which occur in deep-seated igneous rocks where the rate of cooling was much slower. The feldspars from quickly chilled rocks possess a greater compositional range than the corresponding feldspars from rocks that have cooled more slowly. He concludes that many perthitic feldspars are due to the "ex-solution" of the feldspar phases due to decrease in solubility with falling temperature. In the presence of abundant mineralizers the zonal grown crystals become homogeneous and consequently the feldspars from surface rocks show a greater diversity in composition.

In view of the fact that the feldspars constitute a ternary system, Johansson concludes that the common methods of determining the composition of feldspars by optical means are very inadequate.

I agree with Johansson on many of these points and since I have received his paper after the publication of the result of my own studies, (Part I), I am very glad to credit to him the ideas above expressed.

From Sendai, Japan, from the laboratories of the Tohoku Imperial University, come the following two papers:

1. THE INFLUENCE OF TEMPERATURE ON THE OPTIC AXIAL ANGLE OF ADULARIA, YELLOW ORTHOCLASE AND MOONSTONE. Shukustké Kôzu and Masatoshi Suzuki.

2. THERMAL EXPANSION OF ALKALI-FELSPARS. Shukustké Kôzu and Shô-Ichi-Rô Saiki.

These were published in the *Science Reports* of Tohoku University, Series 3, Vol. II, No. 2.

These Japanese investigators find that there is a very pronounced change in the optic angle at various temperatures, roughly, in the neighborhood of 900° which is below the disassociation temperature of most feldspars. The actual temperature of this rapid change depends upon the composition of the feldspar investigated. In the case of adularia from St. Gothard, the temperature of rapid change is about 850°, while the yellow orthoclase from Madagascar was higher occurring at 1075°. It is apparent that the presence of $\text{KFe Si}_2\text{O}_6$ in a potash feldspar raises the critical point.

The second paper on the thermal expansion of the feldspar indicates some changes within the crystal structure on heating. Curves of expansion presented in the papers indicate a number of critical temperatures. There are five points at which expansions or contractions appear at a different rate. These points correspond to the temperatures between 200°C and 300°C, between 450°C and 500°C, between 650°C and 700°C, between 850°C and 900°C to 950°C. Among these points the expansion at 950°C is the most prominent and abrupt changes can be seen on both curves obtained in the two directions, perpendicular to the base and

parallel to the *b*-axis. The author does not offer any interpretation of these results. I believe that any solution of the ever present problem—are orthoclase and microcline mere polymorphous modifications of the same substance, or does the difference depend upon the type of twinning—can only be obtained through investigations of this kind.

The last paper to which I wish to call attention is by E. D. Mountain of the Department of Mineralogy in the British Museum of Natural History. POTASH-OLIGOCLEASE FROM MT. EREBUS, ANTARCTIC AND ANORTHOCLASE FROM MT. KENYA, EAST AFRICA. *Mineralog. Mag.*, June 1925, pages 331-345.

Mountain has collected 68 analyses of potash-oligoclase and anorthoclase and discusses from his plotted results the optical and physical properties of these feldspars in the hope of finding a suitable criteria for distinguishing potash oligoclase from oligoclase. He reaches the conclusion that a classification of feldspars of this range in composition must be purely arbitrary. He has selected 16 from the above that when plotted lie upon a line truncating the albite corner of the Or-Ab-An ternary diagram running from $Ab_{65}Or_{35}$ - $Ab_{65}An_{35}$ and shows a series of diagrams showing the extension angles, specific gravities, refractive index, optic axial angles and curve of cleavage angles. He discusses whether in this range of composition there is only one series of triclinic crystals or whether the potassium component as orthoclase enters into the system to give rise to two distinct series of feldspars of this compositional range. He questions whether there are two series which I advocated in the *Journal of Geology* in 1923. I believe that much more work along the same line that Mountain is doing is necessary before many of the problems of the feldspars can be solved.

NEW MINERALS: DOUBTFUL SPECIES

CLASS: CARBONTAES

"Elatolite"

A. E. FERSMANN: Crystallites of magmatic Calcium Carbonate from Khibinsky and Lovozersky tundras. *Bull. Acad. Sci. Russia*, 17, 251-274 (1923).

NAME: From the Greek *ελάτη*, fir, in allusion to its shape.

CHEMICAL COMPOSITION: The mineral is represented by cavities, the original material having been removed. Believed, however, to have been calcium carbonate.

CRYSTALLOGRAPHIC PROPERTIES: The cavities show a trigonal form.

OCCURRENCE: The original mineral was not found but was represented by cavities in the nepheline syenites of the Kola Peninsula, especially in the north-western portion of the "Umptek massif" and the western part of the "Luyavrut massif."

DISCUSSION: These cavities are believed to represent α calcium carbonate now leached out. Such forms are certainly not deserving of specific mineral names.

W. F. FOSHAG

CLASS: SULPHATES

"Manganolangbeinete"

F. ZAMBONINI AND G. CAROBBI: Sulla presenza, tra i prodotti dell'attuale attività del Vesuvio, del composto $Mn_2K_2(SO_4)_3$. (On the presence, among the

products of the actual activity of Vesuvius, of the compound $\text{Mn}_2\text{K}_2(\text{SO}_4)_3$. *Rend. Accad. Sci. Fis. Mat. Napoli*, **30**, 123-126 (1924).

NAME: In reference to its composition, a *manganese*, potassium sulphate analogous to *langbeinite*.

CHEMICAL COMPOSITION: Contains manganese and potassium. Believed to be analogous to *langbeinite*. Formula: $2\text{MnSO}_4 \cdot \text{K}_2\text{SO}_4$.

CRYSTALLOGRAPHIC PROPERTIES: Isometric, tetrahedrons.

PHYSICAL AND OPTICAL PROPERTIES: Color rose red. Isotropic; $n = 1.572$. Sp. Gr. 3.02-3.03.

OCCURRENCE: Found as small crystals in stalactites of thenardite and halite with sylvite and apthitalite in a cavern formed in Sept.-Oct. 1922 in the lava of Vesuvius.

DISCUSSION: This mineral agrees in properties with the artificially formed salt. Its chemical composition should be further investigated. W. F. F.

NOTES AND NEWS

It is with pleasure that we reproduce the photograph of Colonel Washington A. Roebling as the frontispiece of this issue. The late arrival of the photograph prevented its use in the March number where it should have appeared to accompany the announcement of the Colonel's generous gift.

Colonel Washington A. Roebling has received so many congratulatory letters regarding his gift to the Mineralogical Society that he has been unable to answer them all individually. He has asked that the following statement be inserted in the Journal: "Col. Roebling desires to express his thanks for the grateful appreciation of his gift to the Mineralogical Society from all over the country and Canada. He is pleased that it has been his privilege to contribute to the advancement of this science, a science which is the gateway to the ultimate constitution of matter."

The recent endowment will now permit of an expansion in the size of the Journal. From suggestions already received there seems to be a demand for a larger number of original articles together with a more liberal allowance for cuts and illustrations. Suggestions are invited from all the members of the Society who wish to state their views on the needs that should be given first consideration.

A request has been received for the Journal to publish the names of those members who wish to exchange specimens and thereby enlarge their mineral collections. Those desiring to engage in such an exchange are asked to notify the Editor. The list of names thus obtained will then be printed from time to time in the Mineralogist.